The Status of Ecological Screening Assessments of Brominated Flame Retardants in Canada

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Introduction

The *Canadian Environmental Protection Act, 1999* (CEPA 1999) provides the authority and the requirement to conduct assessments of substances in order to determine if they meet the definition of "toxic" as presented in Section 64 of the Act. A substance is "toxic" if it: (a) has or may have an immediate or long-term harmful effect on the environment or its biological diversity; (b) constitutes or may constitute a danger to the environment on which life depends, or (c) constitutes or may constitute a danger in Canada to human life or health. Environment Canada is responsible for conducting assessments pertaining to parts (a) and (b), while Health Canada is responsible for assessments pertaining to part (c).

Methods and Materials

A screening assessment examines various supporting information and develops conclusions based on a weight of evidence approach as required under Section 76.1 of the Act. The screening assessment presents the most critical studies and lines of evidence supporting the conclusions. One line of evidence includes consideration of risk quotients to identify potential for ecological effects. However, other concerns that affect current or potential risk, such as persistence, bioaccumulation and releases to the environment, chemical transformation and trends in ambient concentrations, are also examined in this report. Ecological screening assessments under CEPA 1999 are completed or underway for the BFRs listed in Table 1.

Results and Discussion

Polybrominated Diphenyl Ethers: Polybrominated diphenyl ethers (PBDEs) comprise a class of substances consisting of 209 possible congeners with 1–10 bromine atoms. Tetra- to decaBDEs were subject to screening assessment under CEPA (1999). These PBDEs are found in different combinations in the Commerical Pentabromodiphenyl Ether (PeBDE), Octabromodiphenyl Ether (OBDE) and Decabromodiphenyl Ether (DBDE) products. PeBDE has been used almost exclusively in flexible polyurethane foam for cushioning in upholstered furniture, automotive seating and carpet backing. OBDE is predominantly used in acrylonitrile butadiene styrene (ABS) to flame retard computer housings, pipes, appliances and automotive parts. DBDE is primarily used in the high impact polystyrene component of electronic equipment housings, and is also the main commercial PBDE product used to flame retard upholstery and drapery textiles (Environment Canada 2006).

PBDEs are not manufactured in Canada. They are however imported in finished or semi-finished articles, in resins, polymers or substrates, or in commercial mixtures that are used in the manufacture of a variety of commercial and consumer products.

The ecological screening assessment concluded that PBDEs (tetra- to decaBDEs) are entering the environment in a quantity or concentration or under conditions that have or may have an immediate or long-term harmful effect on the environment or its biological diversity and are considered to be "toxic", as defined by CEPA 1999 Paragraph 64(a). The tetraBDEs, pentaBDEs, and hexaBDEs are persistent and bioaccumulative in accordance with the CEPA 1999 Regulations, their presence in the environment results primarily from human activity, and they are not naturally occurring radionuclides or naturally occurring inorganic substances. These substances are thus identified for virtual elimination from the Canadian environment under subsection 65(3). A summary of the final ecological and human health screening assessment reports was published in Part I of the *Canada Gazette* on July 1, 2006. PBDEs are now subject to risk management activities in Canada.

Table 1. Current status of ecological screening assessments for brominated flame retardants in Canada

CAS Number	Substance Name	Status of Assessment
40088-47-9	Tetrabromodiphenyl ether (tetraBDE)	Completed
32534-81-9	Pentabromodiphenyl ether (pentaBDE)	
36483-60-0	Hexabromodiphenyl ether (hexaBDE)	
68928-80-3	Heptabromodiphenyl ether (heptaBDE)	
32536-52-0	Octabromodiphenyl ether (octaBDE)	
63936-56-1	Nonabromodiphenyl ether (nonaBDEs)	
1163-19-5	Decabromodiphenyl ether (decaBDE)	
79-94-7	Tetrabromobisphenol A (TBBPA)	Underway
25327-89-3	Tetrabromobisphenol A allyl ether	
4162-45-2	Ethoxylated Tetrabromobisphenol A	
3194-55-6	Hexabromocyclododecane (HBCD)	Underway

Tetrabromobisphenol A and Derivatives: The brominated flame retardant tetrabromobisphenol A (TBBPA) is used primarily as a reactive (chemically incorporated) flame retardant, with small proportion (10%) applied as additive flame retardant. As a reactive flame retardant, TBBPA is largely used in the manufacture of epoxy-laminated printed circuit boards. As an additive flame retardant, TBBPA is mainly applied to ABS resins and phenolic resins. ABS resins containing TBBPA are used in automotive parts, pipes and fittings, refrigerators and other appliances, business machines and telephones (WHO 1995). Ethoxylated TBBPA and TBBPA allyl ether are used in various niche applications.

Globally, TBBPA is the largest selling brominated flame retardant with large recent increases in production (e.g., 300% from 1991 to 2000; OECD 2002). Evidence also suggests that this substance may be environmentally persistent and inherently toxic to non-human organisms. TBBPA degrades only slowly and complete mineralization has not been demonstrated. Bisphenol A and methylated TBBPA, potentially harmful transformation products, have been identified in environmental samples (United Kingdom 2005). TBBPA is harmful to aquatic organisms, with significant adverse effects demonstrated at very low concentrations in species of fish, aquatic invertebrates and algae (e.g., 96-hr LOEC 18 µg/L for Eastern

oyster, *Crassostrea virginica*) (United Kingdom 2005). Exposure to soil organisms significantly inhibited growth in some terrestrial seedling plants and reproduction in the earthworm species, *Eisenia fetida*. Bioconcentration factors of 3200 indicate that under some conditions TBBPA can accumulate in organisms (Great Lakes Chemical Corporation 1989). Few measured data are available for ethoxylated TBBPA and TBBPA allyl ether, however, predictions based on modelled data suggest they will demonstrate properties comparable with those of the parent compound.

Hexabromocyclododecane: Hexabromocyclododecane (HBCD) is a cyclo-aliphatic bromide produced by the bromination of cyclododecatriene (Mack 2004). The resulting technical product is primarily a mixture of three diastereomers (stereoisomers), designated alpha (α), beta (β) and gamma (γ). Commercial HBCD is typically comprised of approximately 80-85% γ-isomer, 8-9% α-isomer and 6% β-isomer. HBCD is an additive type flame retardant used primarily in polystyrene foams that are used as thermal insulation materials in the building industry. A second important application is in the flame retarding of textiles commonly used for upholstery, interior wall coverings and draperies, carpet backing, and automotive interiors (de Witt 2002).

HBCD has been detected in all environmental media and there is evidence that the substance is persistent and bioaccumulative (KemI 2005). While detailed production and use information is not available, results from monitoring studies suggest that North American and global demand for HBCD may be on the rise. As well, time trend analyses conducted using birds and marine mammals document nearly exponential increases in biota levels beginning around the early 1990s. Recently published data report the presence of HBCD in air, sediment and biota samples collected from several sites in the Arctic (de Witt 2006). While this contamination may be local in origin, these findings may also provide evidence that under some conditions and circumstances, HBCD can be transported over long distances and to remote locations.

HBCD has demonstrated toxicity in both aquatic and terrestrial species (for e.g., 21-d LOEC of 0.0056 mg/L for reduced growth in *Daphnia magna*, CMABFRIP 1998), with significant adverse effects on survival, reproduction and development reported in algae, daphnids and annelid worms. In mammals, the liver appears to be the primary target organ and sublethal exposures have been associated with cellular damage and increased hepatic enzyme activity (CMABFRIP 2001). Significant reductions in levels of circulating thyroid hormones have also been documented, further evidence that exposure may negatively impact hormone homeostasis in the body (CMABFRIP 2001).

Next Steps: The ecological screening assessments for TBBPA and its derivative substances, and HBCD are currently underway. When completed in draft form, theses assessments will be published in the *Canada Gazette* and posted on the CEPA Registry web site (www.ec.gc.ca/CEPARegistry/participation) for a 60-day public comment period. After consideration of the public comments, the final report with conclusions will be published in the *Canada Gazette*.

Ecological screening assessments for other BFRs in Canada are being considered through the Existing Substances Evaluation Program at Environment Canada. Further information about this program can be found at the web site, http://www.ec.gc.ca/substances/ese/.

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